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USSR WORK ON PHYSIOLOGICAL ROLE OF NATURAL RADIOACTIVE ELEMENTS

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Investigations of the biological activity of natural radioactive elements have been conducted for some time at the Biogeochemical Laboratory, Academy of Sciences USSR, originally under the direction of V. I. Vernadskiy. Within a short time, it was established by work done at this laboratory that all living organisms (plants and animals) contain radium and other radioactive elements. It was also established that living organisms under natural conditions sometimes have the capacity of concentrating radioactive elements, so that the concentrations of these elements are brought to a level hundreds of times higher then that existing in the surrounding medium.

Since the discovery of radium, considerable work on the biological effects of radioactive elements has been done abroad, but the results of this work have not been conclusive, mainly because insufficient attention has been paid to determination of the optimal dosage. Doses exceeding the optimal ones by millions and even billions of times have been applied. The fact that radioactive fertilizers improve the yield of many plants was established by Stoklaza (1932) and other investigators. However, when radioactive elements were used to fertilize the soil, these elements were assumed to be universal fertilizers, so that other elements needed by the plants were not added.

The mistakes noted above are being repeated at present in work with radioactive tracers. Toxic doses of radioactive phosphorus are being administered in connection with this work. G. Hevesy states, for example, that L. A. Erf

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administered 20 millicuries of P^{32} to a man in order to determine the uptake of this isotope by various parts of the skeleton, and that this man died 19 days later.(1) The authors assume that the man died of leukemia. However, it follows from the work done by the Soviet scientists Ye. I. Bakin and A. I. Naumenko that doses of radioactive elements as high as this have a lethal effect when they act on the organism for 6-15 days.(2) Even lower doses of radioactive elements have a deleterious effect on life processes; application of 10^{-9} - 10^{-12} g of P^{32}, i. e., of quantities which are commonly used in physiological research with radioactive indicators, must be regarded as harmful.

By using radium in quantities of 10^{-11}, 10^{-10}, and 10^{-9}% and by carrying out parallel experiments with radioactive phosphorus applied in quantities which were equivalent to those of radium in regard to radioactivity, we found that these doses of radioactive elements have a beneficial effect on the yield of peas, increasing it by a factor of almost two. Radioactive phosphorus had approximately the same effect as radium, i. e., this effect was produced by the radioactivity of the phosphorus rather than by its mass.

We have studied the effect of uranium X_1, which emits the same beta radiation as potassium, on the yield of agricultural plants and the quality of the crop obtained. Our results show that uranium X_1 exerts the same physiological action on the development of plants as potassium does. When insignificantly small quantities of uranium X_1 which have a radioactivity corresponding to the normal content of potassium in the nutrient medium are introduced, the yield of agricultural plants is increased. This applies to sugar beets, for example. Furthermore, the sugar content of the beets is increased by the action of uranium X_1. However, uranium X_1 alone, or combined with sodium, cannot replace potassium in every respect. On the other hand, potassium cannot satisfy completely the need of plants for radioactive elements.

Experiments on sunflowers, clover, cotton, and other plants showed that the plants do not grow normally and buds do not form if the plants are grown in nutrient solutions which are complete in every respect but which lack radium, uranium, and thorium. We further found that when the nutritive medium is devoid of radioactive elements, the roots of leguminous plants do not develop nodules, although nodule bacteria are present.(3) The plants then are incapable of utilizing air nitrogen. We also found that radioactive elements considerably increase the yields of kok-saghiz and the rubber content of its roots.(4) Sugar beets, kok-saghyz, clover, alfalfa, cotton, flax, and vegetable cultures are particularly easily affected by radioactive fertilizers. However, these fertilizers can in no case replace other substances which are required by the plants.

The radiophotographic method was used by us extensively in studies of the distribution of radioactive elements in plants. The results obtained by this method show that radioactive elements tend to concentrate in those parts of the plants which are subject to the most rapid growth and the most intensive development, i. e., buds, flowers, young leaves, etc.

We may conclude from our data that natural radioactive elements (radium, uranium, thorium, etc.) function as ultra-trace elements. In other words, very small quantities of these elements are effective. Their content in the animal organism is exceedingly small. They are present in soils, in natural waters, and in all plants and animals. Radioactive carbon C^{14} is always present in the air, because it is formed from atmospheric nitrogen under the action of the neutrons of cosmic rays.

Plants in the process of growth resorb radioactive elements from the soil, while animal organisms obtain them from food of vegetable origin. Plants have the special capacity of concentrating radioactive elements after resorbing them

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from the surrounding medium. The action of radioactive elements is multifarious. These elements act on the growth of living organisms and other biochemical processes not by virtue of their mass, which is insignificantly small in comparison with that of other elements needed for nutrition; but by reason of the energy which they emit in the form of alpha, beta, and gamma radiation. The only exception is potassium, which acts on the organism by both its mass and its radioactive energy.

The contemporary state of our knowledge does not permit creation of a nutritive medium for plants which would be completely freed of any effects exerted by natural radioactivity. In particular, one cannot exclude potassium, because plants perish without potassium. This element cannot be replaced by any others. Radioactive elements are always contained in seeds, the purest chemical reagents, the air (radium emanation and C^{14}), dust, etc. This circumstance makes investigation of their physiological role in living organisms very difficult.

Data obtained in our experiments show that the optimal quantities of radioactive elements for plants and nodule bacteria are tens to hundreds of times smaller than the quantities contained in soils. Expressed in curies, this means that the optimum concentrations are 100-1,000 times smaller than 1 millimicrocurie [per ml]. However, plants can stand higher concentrations of radioactive elements of the order of millimicrocuries. Although concentrations of this order do not strongly inhibit the growth of plants, neither do they stimulate it. Doses of radioactive elements which amount to millicuries or microcuries are harmful for living organisms because of their excessive radioactivity. Application of such doses is not permissible, particularly when their action on the organism is prolonged.

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